



Fisheries and Oceans
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Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2014/048

Pacific Region

Proceedings of the Pacific regional peer review on the Stock Assessment and Harvest Scenarios for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for the 2013 and 2014 Seasons

**January 29-30, 2013
Nanaimo, British Columbia**

Chairperson and editor: Sean MacConnachie

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

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csas-sccs@dfo-mpo.gc.ca](http://www.dfo-mpo.gc.ca/csas-sccs/csas-sccs@dfo-mpo.gc.ca)



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ISSN 1701-1280

Correct citation for this publication:

DFO. 2015. Proceedings of the Pacific regional peer review on the Stock Assessment and Harvest Scenarios for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for the 2013 and 2014 Seasons; January 29-30th, 2013. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2014/048.

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SUMMARY

Pacific sardine (*Sardinops sagax*) from the Northeast Pacific (California Current) population has a distribution that can range between Baja California to southeast Alaska. In winter and spring months, most of the sardine population resides in waters off the California coast. Prior to and during summer months, large aggregations of sardine migrate from key spawning habitat to more northern waters, but migratory patterns can be affected by population size and oceanographic conditions. Typically, most sardines that migrate into British Columbia (BC) waters are the larger and older component of the population.

Fisheries & Oceans Canada has been applying a Fishery Management Framework using a harvest control rule that sets the annual total allowable catch (TAC) of sardine based on annually updated biomass estimates of age 1 year and older (1+) fish in the population, an estimated average seasonal migration rate of sardine into Canadian waters, and a regional harvest rate.

Since 1997, an index of the biomass of the migratory component of the sardine population has been determined from an annual summer surface trawl survey off the west coast of Vancouver Island. The index is based on average sardine densities observed for the region, measured in t/km³. Biomass estimates for unsurveyed areas have been calculated by extrapolating annual trawl survey densities to areas of current and recent fishing grounds.

Both DFO and the sardine fishing industry are interested in exploring alternative approaches to the provision of harvest advice that does not rely on the annual trawl survey. To address these multiple interests, both the provision of harvest advice and alternative approaches for the provision of harvest advice was examined.

Compte rendu de l'examen régional Pacifique de l'Évaluation du stock de sardines du Pacifique (*Sardinops sagax*) dans les eaux de la Colombie-Britannique pour les saisons 2013 et 2014 ; les 29 et 30 janvier 2013

SOMMAIRE

L'aire de répartition de la sardine du Pacifique (*Sardinops sagax*) de la population du Pacifique Nord-Est (courant de la Californie) se situe entre la Basse-Californie et le sud-est de l'Alaska. En hiver et au printemps, la majorité de la population de sardines vit dans les eaux au large de la côte californienne. Avant et pendant l'été, de grands rassemblements de sardines quittent les principales frayères pour migrer vers des eaux plus au nord, mais les habitudes migratoires peuvent être modifiées en raison de la taille de la population et des conditions océanographiques. En général, la majorité des sardines qui migrent dans les eaux de la Colombie-Britannique (C.-B.) sont les individus les plus gros et les plus âgés de la population.

Pêches et Océans Canada a mis en œuvre un Cadre de gestion des pêches utilisant une règle de contrôle des prises qui établit le total autorisé des captures (TAC) annuel pour la sardine en fonction des plus récentes estimations annuelles de la biomasse des sardines âgées d'un an et plus au sein de la population, d'une estimation du taux moyen de migration des sardines dans les eaux canadiennes, et d'un taux de récolte régional.

Depuis 1997, un indice de la biomasse de la composante migratoire de la population de sardines a été déterminé d'après un relevé annuel au chalut de surface effectué en été au large de la côte ouest de l'île de Vancouver. L'indice est fondé sur les densités moyennes de sardines observées pour la région et mesurées en t/km^3 . Les estimations de la biomasse dans les zones n'ayant pas fait l'objet de relevés ont été calculées en extrapolant les densités des relevés annuels au chalut en des zones des lieux récents et actuels de pêche.

Pêches et Océans Canada et l'industrie de la pêche à la sardine souhaitent tenter d'autres approches pour formuler des avis sur la pêche qui ne soient pas fondés sur un relevé au chalut. Afin d'aborder ces nombreux points d'intérêts, on a examiné la formulation d'avis concernant les pêches et les approches de rechange pour la formulation d'avis concernant les pêches.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on January 29th and 30th, 2013 at the Pacific Biological Station in Nanaimo, BC to review stock assessment and harvest scenarios for Pacific Sardine (*Sardinops sagax*) in British Columbia waters for the 2013 and 2014 season.

The meeting Chair, Sean MacConnachie, welcomed participants, and initiated a round of introductions. The Chair then explained meeting logistics and reviewed the role of CSAS in the provision of peer-reviewed advice. It was also noted that management, economic and social decisions are not addressed through CSAS processes. The Chair discussed the role of participants, the purpose of the various RPR publications that will result from this process (Research Document, Science Advice Report and Proceedings), and the definition and process around achieving consensus. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions. It was confirmed with participants that all had received copies of the Agenda, Terms of Reference, working paper and reviews.

Vanessa Hodes was identified as the Rapporteur for the meeting. The Chair then reviewed the Agenda (Appendix A) and the Terms of Reference (Appendix C) for the meeting.

Participants were informed that Dennis Rutherford and Jim Thorson had been asked to provide detailed written reviews of the working paper to help guide discussions during the peer review meeting. Participants were provided with electronic copies of their written reviews in advance of the meeting.

The resulting Research Document and Proceedings will be made publicly available on the CSAS Science Advisory Schedule at the [Canadian Science Advisory Secretariat website](#).

REVIEW

Rapporteur: Vanessa Hodes

Presenter: Linnea Flostrand

PRESENTATION OF WORKING PAPER

This working paper resulted from discussions of the Pacific Sardine Science Working Group meetings. Information in the presentation included:

- The life history of the Pacific Sardine followed by population distribution along the California Current and a discussion of Pacific Sardine historical abundance based on scales found in sediment cores off California.
- A review of the US Pacific Sardine population assessment. This assessment incorporates US fishery catch data, research survey data, and uses a length/age structured model. The results provide age 1+ and older population biomass estimates. The 2012 results show a decrease in age 1+ biomass from 2011. Over the past 10 years, there are three estimates of relatively strong year classes: 2003 (strongest), 2005, and 2009.
- The US harvest guideline was described, where
- $TAC \text{ (Total Allowable Catch)} = (\text{Biomass} - \text{Cutoff}) * \text{fraction} * \text{distribution factor}$
- The history of BC's Pacific Sardine Harvest control rule (HCR)
 1. 1999: experimental fishery guideline
 2. 2001: proposed guideline for a commercial fishery opening in 2002; migration rate and a harvest rate using US fraction and WCVI trawl survey densities (2001)
 3. 2010: average migration rate updated based on survey biomass and US 1+ biomass; recommended after excluding anomalous surveys (including low densities) using rolling average migration rate (MR) parameters.
 4. 2011: inlet extrapolation included in MR parameters
 5. 2012: recommended future work to explore alternative harvest control rules and alternative biomass forecasting; explore migration rate estimates based on comparable age and length components of the population and using the acoustic trawl (US) survey biomass estimates.
- Canadian Trawl survey length data was compared to the Canadian commercial seine fishery biosamples. The majority of fish in the commercial seine fishery and WCVI trawl survey samples were >20cm.
- The Canadian Pacific Sardine age data was presented showing trends from 1999 to 2012. There are years where younger fish have been present in trawl survey catches. The authors addressed one reviewers comment regarding weighting the age samples by survey effort. Authors agreed that the weighted age sample results can be added to the paper for clarity.
- Pacific Sardine length-age relationships, with using both the Canadian and US data, were discussed; it was agreed that 20cm fork length (FL) is generally an age 2+ fish.
- The authors presented a slide tracking Pacific Sardine biomass using different population components: age 1+, 2+, 3+ and 20cm FL. The presentation continued with a description of the Acoustic Trawl Survey (US). The track lines and point sets from the acoustic trawl

surveys in the California Current were shown. In 2012 the survey went as far north as WCVI. Biomass estimates from this survey were high in 2006 and lower during 2010-2012.

- The authors provided an overview of the 2012 WCVI Pacific Sardine trawl survey. The presenter explained the development of the core sampling region, and the establishment of random sampling in the 8 regions. She provided an overview of the sets made during the 2012 survey; 88 total, 4 in the inlets and 13 replicate sets. GeoEye data showed that chlorophyll increased after the survey and that SST also increased after the survey as well as mean monthly SST which showed 2012 was cooler than previous years.
- From the survey data, two ways of calculating Pacific Sardine survey catch density were explored: raw pooled and stratified. Both showed similar outcomes. Raw pooled estimates were used in the working paper.
- The authors outlined that Pacific Sardine biomass is estimated by adding the core survey region biomass estimate to the inlet extrapolation estimate. A table and chart outlining WCVI Pacific Sardine survey biomass estimates from 2006-2012 was presented. The authors stated the 2012 BC biomass estimates showed a decrease from 2011 estimates. It was noted that it is unknown if this low biomass is due to decline in stock, and/or survey timing and environmental factors.
- The authors reviewed annual and average migration rate (MR) estimates. Annual migration rate estimates for the US biomass and the acoustic trawl survey biomass with multiple age or length population components describing a MR ranged from <10% to 34%.
- Canadian annual migration rates were discussed. In addition to annual estimates, the average migration rates were also provided for multiple years (2006-12 and 2006-11) and for rolling 2 or 3 year averages depending on survey data availability. The MR generally declined after 2006. MRs of age 1+ fish ranged from 10-27%. It was noted that for older population components, MRs were generally higher.
- The authors presented US fishery exploitation landings from 1981-2011 which included landings from Mexico, US, and Canada. Catches in Mexico and Canada increased during 2009-2011 while catches decreased in the US. The statement was made that US catches decreased in 2012, however this was incorrect. It was clarified that in 2012, the US had close to double 2011 landings (98,000t) and that there is no available information on catch from Mexico for 2012. Canadian catches followed a similar trend to 2011.
- It was noted that increased Canadian fishing effort was due to management changes in 2009 (e.g. sharing of catch, ease of landing, increased TAC etc).
- A summary of the estimated realised Canadian commercial Pacific Sardine catch by DFO Pacific Fishery Management Areas from 2006 to 2012 was provided.
- Multiple summaries of estimated exploitation rates were outlined in the presentation.
- Multi-year average (2006-2012) TAC-based and landings-based BC fishery estimates of BC regional exploitation rates were $\leq 22\%$.
- Fishing effort and TAC increased during 2006-2011. Mean estimates of exploitation rates for age 1+ and 2+ are <3%. For comparison, the landings from the Pacific North West have means of approximately 6%. A slide was presented showing US and BC combined TAC and landings based age 1+ population exploitation rates.
- Four harvest control rule scenarios were presented:
 1. Varying migration rate (MR) estimates, based on past years' estimates Three different ways of estimating the migration rate were presented:
 - 1.1 MR= annual estimate (Past year observation)

-
- 1.2 MR= rolling average (past 2-3 year observations)
 - 1.3 MR=Average of 2006-2012
 2. Fraction of population biomass (3-5%)
 3. Fraction of population biomass (3-5%) after subtracting 150,000 t cutoff from age 1+ biomass.
 4. Constant TAC, 15,000-45,000 t

Concluding points in presentation

- The US led assessment has shown a decline in population biomass from a peak in 2006.
- There has been a declining trend in BC survey biomass and migration from 2006 to 2012 with only a slight increase in 2010 and 2011.
- The 2012 survey demonstrated particularly low biomass and migration in BC possibly due to oceanographic conditions, anomalous ocean conditions during the July survey or a declining population biomass.
- Estimates of multi-year BC fishery average regional exploitation rates (<22%) are generally conservative relative to temperate pelagic forage fish in other countries where some annual harvest rates can be up to 50%.
- Mean and annual BC fishery population exploitation rates are estimated to be less than 5%.
- Authors recommend against Scenarios 1 and 4 and suggest that Scenarios 2 and 3 are preferred HCRs.
- The authors outlined pros and cons for each scenario and presented a table showing TAC options in tonnes for the 2013 fishing season in Canada.
- Uncertainties in the BC and the US stock synthesis (SS) biomass estimates: Survey timing, catchability, 30m depths assumption, expansion throughout region and unsurveyed areas, SS Biomass indices, mortality estimates, length and age relationships, recruitment estimates, HCR inclusion of a dated age 1+ estimate.
- Future work should be directed towards development of a population wide MSE with performance measures that include the BC fishery.
- Important to continue the collection of BC sardine biological data (survey and fishery) and ecological and oceanographic data in order to continue the time series.

GENERAL DISCUSSION

POINTS OF CLARIFICATION

International Exploitation Rates

Discussion occurred regarding Figure 6. Fishery Exploitation: landings 1981-2012. There was confusion in determination of the total exploitation rate for all three countries. Kevin Hill clarified that the total exploitation rate for the entire stock including Mexico was 15-16%. Canada's exploitation rate is approximately 5%, the combination of US and Canada is 12%.

Population components and migration rates estimates

Inclusion of estimates of migration and exploitation rates for different population age or size components was a recommendation from the 2011 review. The acoustic trawl survey estimates were proposed as being more empirical and less confounded than SS estimates. Conversely, investigating SS components estimates of the population of comparable size and age as those seen in BC waters was also suggested.

US Distribution

The US distribution factor of 87% was defined from averaging two different historical surveys that occurred prior to the Pacific sardine recovery when they were not in Canadian waters, and was based on the assumption that there was only one stock. The US will be reviewing this factor despite the lack of data from Mexico. Originally, the 13% difference was to account for Mexico, therefore Canada was not considered.

DFO Fishery Management Objective 4

Objective 4 should be reframed to encompass the need for stability on deciding an agreed upon harvest control rule. It needs to be explained that the goal is to achieve stability in the process rather than the TAC.

REVIEW # 1

The authors were commended for their hard work. The reviewer found significant problems with the methods portion of the review.

Age and length composition

Issue: Age and length composition was not weighted by catch despite the survey being a stratified survey.

Response: The work has been done and it does not show much difference and as a result it was not included in this paper. Authors agreed that the weighted age sample results can be added to the paper for clarity.

Equations

Issue: The lack of equations in the methods section made it difficult to follow the process. The term modelled was used however there were no equations. If text is used to document the model, then the authors should use bullets or have a section outlined by steps.

Response: The authors agreed to clarify the methods section and add the required equations.

Language Use

Issue: The of the word scenario, simulation, model and mimic used interchangeably made the paper confusing.

Response: The authors agreed to go through the paper and be more consistent throughout.

Precautionary Approach (PA)

Issue: None of the 4 HCRs presented are compliant with DFO precautionary approach (PA). Any new HCR should relate to this. Figures need to be referred to the three zone framework of the PA.

Response: Authors agreed to clarify how the HCR addresses the PA in the paper.

One approach that was discussed by authors prior to the writing of the paper was whether a report card approach might be worthwhile to advise on fishing at different levels given different productivity indicators. But there was not sufficient time to come to consensus in the working group to apply these principles or to investigate the use of a reference value; therefore they were not included in the paper.

The reviewer stated that it does not have to be solely the BC component that fits into the PA, the overall assessment could be put into the PA.

Science responded that the US has a harvest control rule that does encompass aspects of the PA. It is unknown how something can be established specific for BC.

The reviewer suggested adding more on the US harvest control rule into the paper, to which authors agreed.

US 150, 000t Cutoff

The origin of the US 150,000 t cut-off was discussed. The 150, 000 t cut off was a multiple of the overfished level that was determined to be 50,000t. The validity of 50,000 tons is debatable. It is thought to be the biomass that produces $\frac{1}{2}$ of the virgin recruits. The decision came after extensive simulations and evaluation of 13 alternative options and is described in the 1998 US Management Plan.

The chair stated that this is a conservative number to increase the likelihood of the long-term health of the Pacific Sardine stock.

Issue: The 150,000 t cutoff should be included in any HCR. The rationale for not including the cut-off needs to be explained further in the paper. Since the paper relies on U.S. stock synthesis assessment results and the 15% regional harvest rate parameter was based on the US level, it was unclear why the cutoff was not included in past HCR calculations.

Response: The original paper and review (1999) included the cutoff, but it was excluded in future years, possibly as an oversight. A suggestion was made to elaborate on how scenario 1 was established and the rationale for moving away from that scenario.

Statement: The paper seemed to be largely an industry and management exercise. The methods are not generally related to sustainability. The paper contains no biological or conservation objectives. The reviewer felt that there should be no science advice coming out of this document. The authors have applied the arithmetic but there is a lack of evaluation against biological and science based objectives.

Reference Use

Issue: The reviewer found fault in the use of the Zhang paper as a reference and it was suggested that this reference be removed.

Response: The authors were looking at the shape of the curve and how it was similar to the scenario, but agree that the reference points are different. Authors stated the reference will either be removed or rephrased it to clarify its inclusion.

Current HCR

Issue: The rationale for including the current HCR as an option eluded the reviewer.

Response: The rationale for including the status quo is for comparison to the proposed alternatives.

Statement: Why would the current HCR be discontinued, there is no supporting analysis to show that the current method isn't appropriate.

87% Distribution Factor

Issue: Why wasn't a 87% distribution factor (characterizing an average 13% net loss of population biomass in to Mexican waters considered in a HCR? An obvious option for HCR is to fully embrace the US assessment and assume the 13% outside US and Mexico and apply this to the Canadian proportion.

Response: US has planned a review in early 2013 to discuss the estimation and application of this factor in the HCR. The authors can clarify this in the paper with a bit of background information on how the 13% was derived and how it was applied to Mexico rather than Canada.

A discussion occurred on how the Science Working Group selected the four options included in the paper. The group was looking for a simpler HCR that used fewer DFO resources. Four scenarios were agreed upon as sufficient to explore for this paper.

Basis of advice

Issue: The advice should be stock status based.

Response: Performance measures were not pre-defined for assessing each of the proposed scenarios, so the authors attempted to look at what performance measures could be used, such as variations in TACs or exploitation rates (ER). The ERs are an indication of the effect on the stock.

MSE

Statement: MSE seems a long way off after reading this paper. There are no evaluation parameters articulated in this paper. There seems to be a feeling that MSE will answer a lot of questions. It's expensive, there is not a lot of expertise, and it's uncertain there would be benefits unless the infrastructure is there to go down that route.

The question was raised on how MSE can be discussed for a transboundary fish without an international agreement. The response was that an initial US MSE discussion is planned for February, 2013. Any long term stock-wide initiative would be discussed at the Tri-national Forum or through a bi-national agreement. It was noted that there are many concepts about how to implement and conduct a MSE. Something simpler could be attempted with equally useful results. A simulation that doesn't have a full closed loop with management actions could be attempted. It would be a one way link. There is a simpler step between this paper and a full MSE.

Terms of Reference

Authors agreed to clarify linkages between the working paper and the TOR.

Time Series

The BC Pacific Sardine time series is relatively short (10 years) and the migration issue could be addressed with simulation modelling. The problem with presenting 10 years of HCRs is that

there is only one small window of dynamics for the stock. It is not convincing that the realised outcomes are representative of how the stock would perform in the future.

Performance Variables

One author stated that performance indicators are typically comparing results to well-articulated objectives. These objectives could be developed over the next year or two. This is something that could be outlined as a recommendation that we would work on in the next few years. This needs to be done for the whole population.

Review Summary

In summary, there are two themes coming out of the discussion: The paper is not PA compliant for this stock assessment and performance measures to compare scenarios do not yet exist.

The authors have agreed to clarify the PA linkage to the paper. A recommendation for future work included simulations to address testing scenario outcomes in association with performance measures.

REVIEW # 2

The reviewer generally agreed with the rationale in the paper for the different HCRs based on priority reasoning. He was not sure that the presentation of the scenarios provides strong support for one HCR over another and feels the time series is too short. He found, after listening to the presentation as well as the first review that he agrees with many of the other reviewer's points.

Environmental Variables

Issue: Scenario 1 is being done with a model based rolling average migration rate. Scenario 2 and 3 could be improved using an age specific migration rate. 2012 MR is considered debatable due to temperature. This suggests rather than removing years, you should include temperature in the model which allows you to characterise your uncertainty.

Response: There was some agreement among the committee on this issue. It was reinforced that the focus of the paper was to move away from estimating annual MR for two main reasons: the issue of the 2012 survey uncertainty due to environmental conditions and the ongoing debate whether the survey is capturing the Pacific Sardine biomass adequately. Scenario 2 and 3 were developed to combine HR and MR into one estimate.

Reviewer comment to response: Main concern stems from the short time series of the data. Ten years of data might not be representative of the future. MR might change in a systematic way.

Further Comments: It was stated from a scientific point of view it is interesting to see what factor (environmental or other) is driving the MR.

One author has concerns with all of these suggestions with the anticipation of reduction in staff and ultimately of resources. Another author stated that these issues need to be addressed through simulation models because of these reductions.

Sardine Trawl Survey

Issue: If there is an annual variability in the MR that is caused by temperature, reducing survey frequencies can cause error within sampling over the year, drastically decreasing useable sample size within a year. As a result sampling every year is a good idea. A discussion of

changing the sampling design depends on the proportion of samples and cost of samples. The reviewer felt there was not enough information to evaluate decreasing the frequency of the survey.

Response: The focus of the paper is to move away from the yearly estimation of MR. The statement was made that the biomass survey was not necessary if we are not doing yearly MR. The proposal was to do the annual trawl biomass survey every two years.

The reviewer stated that at some point the HCR will have to be simulation tested and this will depend on defensible justification for MR. The reviewer suggested a power analysis would be justifiable before changing sampling protocol. The ratio of variance would be important in a power analysis.

The relevancy of discussing the frequency of the survey or change of sampling protocol was questioned. The topic was not on the agenda and was not part of the intent of the meeting. One author argued that the decision made at this review will directly impact the survey, despite not being on the agenda, the topic will be discussed at a later time.

A member requested there be discussion regarding the utility of some years of Pacific Sardine surveys, including the timing of the surveys. We know that Pacific Sardine migration is dependent on ocean conditions; the stock expands and contracts on multi-decadal scales, migration is highly variable.

The discussion revolved around using the trawl survey to determine other science issues. It was brought up that there is no analysis on what the financial and statistical cost would be to stopping the current survey. However valuable this question may be, one participant stated, the paper does not give the scientific information to evaluate the reliability of methods on the annual survey. There are no boundaries for this discussion in this forum.

Stock Forecasting

Issue: Harvest advice in BC is based on the SS model that is developed the prior year. That one year lag between assessment and management seems especially important. The reviewer suggested forecasting using the SS model.

Response: One author feels that projection is a good idea.

The US is currently exploring this option. Another author supported this approach, stating that if the US is moving that way, and Canada will most likely follow.

Kevin Hill has been proposing this in the US, basing management on a more real time estimate. The SS does produce a biomass for the calendar year; projections would have to be made beyond that. He encouraged Canada to continue discussion about using population projections for management. It will be coming up in another meeting in April.

Review Summary

The Chair summarized that there are two questions:

- i. decision on using migration rate or not
- ii. frequency of doing trawl surveys.

Summary of discussion:

The paper does not have defined performance measures to compare and evaluate the scenarios against. The committee needs to come up with some approaches on how to evaluate

this paper despite this gap. It appears that there is only the 4th scenario that is to be evaluated against the status quo but there is no basis for objectively making that comparison. There was some discussion around the rationale for including the migration rate in the HCR. The authors indicated that that the species is dependent on oceanographic conditions, going to a population based harvest rate is probably the most appropriate method, since it may track the productivity of the stock.

DFO MANAGEMENT

The Chair brought the discussion back to DFO management. There are 4 different scenarios presented in this paper for management to consider. The DFO Sardine manager stated in terms of the 4 scenarios, there are two that meet the management objectives set out in beginning of the paper through the Science Working Group. The working group was looking for something more predictable while taking into account the US stock assessment (best advice).

Using one of these proportional HCR (2 or 3), makes sense to management. There was discussion around the objectives of the working paper and by going to a multi-year assessment and reducing variability in exploitation rates, do the scenarios meet those objectives. Tables 10-13 attempt to address this issue though there is no statistical analysis comparing exploitation rates. It was argued there is nothing in the paper which demonstrates that any scenario provides less variability than another and there is no feedback whether variability is good for the stock. This paper is offering a choice for the managers. It was noted that an opinion as to which one is a good choice can come from the working group as the members are familiar with the data. A reviewer felt that the panel cannot decide on the best choice. The paper does not outline how they compare.

Recommendation: There should be some performance metrics. These could be items such as variability of catch, risk of overfishing, risk of entering overfished status outlined for each scenario. For scenarios 2 and 3, they would have this for each level of HCR.

Chair: Can we build a consensus on eliminating any out of the four?

Scenario 4 conceptually doesn't make sense. Not responsive to changes in stock biomass and not precautionary. There was consensus within the group that HCR 3 is superior to 2. Scenario 1 is the status quo and Scenario 3 is plausible to present to management.

DISCUSSION:

- A member of industry stated that the 150,000 t number is not a real number. Last time the Pacific Sardine disappeared from Canadian waters, there was still 300 000 t remaining in the US. Is there any real scientific justification of keeping the 150,000 t buffer? One author stated including the 150,000 t as something closer to PA principle, because net harvest rates decrease with decreases in biomass estimates.
- It was noted that Canada is fishing at a conservative rate compared to other jurisdictions; as a result looking at scenarios 2 and 3 should meet the manager's needs. However, work on developing performance indicators that can be examined over the next few years should begin.
- Reviewer two agrees that scenario 2 and 3 have a stronger theoretical basis. He questions making a change in a HCR without a stronger reason. The risk is that it seems like migration rates are going down over time and maybe that makes sense. There is a scenario in which migration rates may continue to go down. HCR Scenarios 2 and 3 lock in constant views of

migration and harvest rates. This type of change in HCR needs something more than a theoretical basis.

- One author noted the use of a cut-off or a buffer will absorb some of the population size issue. This provides a good case for picking Scenario 3. Scenario 3 is considered the most scientifically (theoretically) viable. Ultimately, the majority of the panel may agree on Scenario 3, but it is uncertain there is enough scientific confidence in giving that advice. The choice is up to the managers.
- The Chair summarised: Due to the lack of simulation results of one scenario over another, scenario three, is more precautionary with the 150, 000 t buffer.
- Reviewer 2 stated that even the three year rolling average is a model based estimate of MR. All of these methods reduce interannual variability by increasing the bias between ideal and real MR. Scenario 3 is more justifiable than Scenario 2 because it provides a conservative buffer.
- An author stated that Scenario 3 is a little more risk adverse compared to using the same population harvest rate parameter without the cutoff.
- One author stated that Scenario 1 does not track the stock well. There is a tremendous amount of variation with scenario one.
- The US HCR uses the assumed constant fraction. Using variable migration rates would increase the risk of overexploiting the resource. The caveat was added that evaluating this is not possible without simulations.
- One author stated the status quo does not have the 150, 0000 t cut off included in its calculation. As a result, it is not applying PA principles.
- A reviewer stated that this paper should be titled "Evaluation of the ability of the WCVI Pacific Sardine trawl survey to estimate migration rates"
- One author said the same arguments were discussed last year and that the authors were tasked with developing something new, it was done and now people are saying go back to last year. There is literature that supports this approach. We need to do more and come to grips with well-articulated objectives but right now we have this paper.
- Reviewer one stated that science can't endorse one scenario over another based on the paper. It should be handed to the managers. A science advisor responded that the sub-committee has the ability to make a recommendation whether or not one scenario should be excluded, even if the words do not exist in the paper as a piece of advice to fisheries management.

Sardine Population Age Components

- Trying to include HCRs associated with age 2+, 3+ population components in the paper was thought to be too complicated at this stage. It was noted that if considering age 2+ biomass in a prospective HCR, that associated MR rates should be considered
- One author discussed the issues from a stock perspective. Canada has taken approximately 20,000 t, Oregon and Washington have taken 2-4 times more, and historically have taken 5-40 times more and they also fish on age 2+ fish. What would be the benefit of Canada taking the brunt of a reduction in TACs? California has mostly fished on age 1 and age 2 fish. If we are looking to develop this on a conservation level, we need to be working with US.

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- It was stated that in this paper the Pacific Sardine are all age 2+ in Canadian waters, and harvest control rules ignore this data. One author responded there were suggestions to track this; she believes we should be leaning towards considering these views in the future.

SAR review

- The figure one caption is incorrect.
- Reviewed the harvest options
- Table 3 needs to be more specific and have all the results from 1.1-1.3 or the caption must address that this table is only 1.2 not the rest of the 1.
- There was a consensus to remove the term "maximum" when discussing harvest rate (it was a legacy from past advice formats).
- Sources of uncertainty:
- Should we add the uncertainties of the management performance of the different harvest control rules?
- Add concern with 2012 survey to the first paragraph of the uncertainties.
- Rather than excluding years, a solution would be to make a model using temperature which would account for these odd years.
- It is recognized later on and is something that needs to be addressed. We need to add this to lead into the recommendation.
- Suggest deleting the line about sea surface temp as it was from 2011. Rewrite to represent 2012. Chair added "related to ocean conditions".

General comments and future work suggestions

- The performance of the HCR will depend on migration rate and what is driving the Pacific Sardine, an operating model could simulate MR using a covariate such as ocean condition or age structure. There are a few hypotheses in the paper of what might drive migration rate.
- Estimate the link between migration rate ocean conditions and age structure use it to simulate future changes in migration given changes in these variables. This would be the structure of the simulation.
- A power analysis to explore different sampling schemes and shows how outcomes are affected. It can give you a cost benefit outcome.
- Conduct analysis on reducing the frequency of the trawl survey for biomass estimates to bi or tri annual.
- It was suggested to continue using the survey to evaluate the risk of a HCR decision by continuing to build the dataset. Survey design can be modified while retaining some level of survey effort to assess the approach. Some level of survey effort should be maintained in BC to verify that the distribution of Pacific Sardine is what is assumed.
- In the earlier part of the document, authors have some text around the fishery management objectives. Providing background at the front describing the purpose of the work would be good.
- Is it being suggested that this year the annual survey is cancelled or that a power analysis is done before dropping the survey? The suggestion was made to evaluate before cancelling the survey. One author stated in any given year you have enough variability between areas, that reducing the days and sets would be too variable to keep the surveys consistent. The

abridged survey will provide less information. Some level of survey effort should be maintained but what it looks like is to be determined.

- HCR's 2 and 3 could be used for advice as they are not dependent on the survey.
- Industry is going to ask for a compromise when they are paying for everything. These statements will have to be in the paper but tough decisions will have to be made.
- There was a recommendation that this survey is to be continued for one more year at the US survey review last year. A migratory index needs other covariates with it.
- A statement such as: The value of continuing with some level of BC surveys if scenario 2 and 3 are chosen must be evaluated, could be included.
- It can't be said what is needed for the survey work at this time. It can be left saying an evaluation needs to be done to the value of the survey if 2 and 3 are chosen as harvest advice. This gives science time to address these issues
- One author stated that another year of data would assist in addressing the other issues.

Recommendations

Three of the scenarios were found to have a scientific basis for the provision of scientific advice, however, there was insufficient information to recommend a single scenario from among the other three scenarios. Specific considerations for each scenario and additional management advice are outlined below:

- HRC Scenarios 1-3 were found to have a scientific basis for the provision of scientific advice. Scenario 4 HCR was rejected because it is not sensitive to variations in population biomass and is not precautionary.
- From the available literature there is a theoretical basis to support Scenario 2 and 3 HCRs because they decrease inter-annual variation in realized exploitation rates. Further improvements that could be made to decrease interannual variability in migration rate estimates using available data, but which would require additional research to implement.
- Scenarios 2 and 3 HCR may allow for population harvest rates to vary differently compared to regional harvest rates resulting from Scenario 1 HCRs.
- No recommendation on a preferred HCR scenario was possible (of Scenarios 1-3) because performance measures to evaluate HCRs have not been identified for this fishery and stock and because performance measures would need to be evaluated in the context of a dynamic operating model, which is lacking.
- No specific recommendation has been made for population harvest rates for Scenarios 2 and 3 HCRs. A range in population harvest rates of 2-5% for Scenarios 2 and 3 HCRs encompasses 1) realized estimates of 2006-2012 age 1+ population exploitation rates, and 2) values resulting from the product of estimated annual migration rates (2006-2012) and a 15% regional harvest rate. However, realized values from past years will not reflect current conditions if migration rates are changing significantly over time.
- In order to provide further advice on the scenarios considered, it would be necessary to identify performance measures to evaluate HCR scenarios in a population-level management strategy evaluation (preferably in conjunction with the U.S. and Mexico) or a simpler BC-level simulation study (e.g., including covariates, such as ocean conditions).
- If Scenarios 2 or 3 harvest control rules are considered, an analysis should be undertaken to determine the risk of reducing the frequency of the annual trawl survey and associated implications on the robustness of the advice.

-
- Efforts should be made to continue the collection of B.C. sardine biological data (survey and fishery samples) and ecological and oceanographic data.
 - Fishery Managers are advised to consider uncertainty associated with biomass forecasting for the fishing season starting in 2013. They are also advised to consider uncertainty associated with localized ecosystem attributes, such as incidental harvest of other species and removal of sardine from important forage habitat of sardine predators.
 - An assessment of the impact of using population age 1+ biomass in the B.C. fishery HCR, when most fish in B.C., Washington and Oregon waters are primarily age 2 and older, is recommended. Additionally, it is recommended that, in conjunction with the U.S., an assessment of the impact of fishing components of the population off California and Ensenada Mexico that are less than age two is conducted.

ACKNOWLEDGEMENTS

The chair of the meeting would like to thank the authors for their hard work, the reviewers for their constructive comments, and the participants for their active engagement in the review process. Thank you to the CSAS office for help in coordinating the meeting. Thanks to Vanessa Hodes for rapporteuring.

APPENDIX A: AGENDA
PACIFIC SARDINE
Regional Advisory Process
Centre for Science Advice Pacific

January 29-30, 2013
Nanaimo, British Columbia

Chairperson: Sean MacConnachie

Working Paper to be reviewed:

Evaluation of alternative approaches for providing harvest advice for Pacific sardine in British Columbia Waters: 2013 and 2014 Seasons by Linea Flostrand, Jake Schweigert, Jennifer Bolt, and Sandy MacFarlane.

Day 1

9:00 Introductions Sean MacConnachie
9:10 Review Agenda & Housekeeping Sean MacConnachie
9:20 CSAS Overview & Procedures Sean MacConnachie
9:30 Presentation of Working Paper Linea Flostrand
10:30 Break
10:50 Questions of Clarification RAP Participants
11:00 Presentation of Reviews & Authors' Responses Reviewers & Author(s)
12:00 Lunch Break
1:00 Discussion RAP Participants
2:30 Break
2:50 Discussion RAP Participants
4:30 Adjournment

Day 2

9:00 Introductions Sean MacConnachie
9:10 Review of Day 1 Sean MacConnachie
9:20 Discussions RAP Participants
10:30 Break
10:50 Review Science Advisory report:
Building Agreement on Conclusions,
Recommendations, Advice and Future Work
RAP Participants
12:00 Lunch Break or adjournment

APPENDIX B: ATTENDEES

Last Name	First Name	Affiliation	Attend Jan 29	Attend Jan 30
DFO Participants				
Bassett	Sandra	DFO, Science	A	A
Boldt	Jennifer	DFO, Science	A	A
Cleary	Jaclyn	DFO, Science	A	A
Edwards	Andrew	DFO, Science	A	A
Flostrand	Linnea	DFO, Science	A	A
Hargreaves	Marilyn	DFO, Science	A	A
Hodes	Vanessa	DFO, Science	A	A
MacConnachie	Sean	DFO, Science	A	A
Mah	Jordan	DFO, FAM	X	W
McFarlane	Gordon (Sandy)	DFO, Science	A	A
Mijacika	Lisa	DFO, FAM	X	A
Rutherford	Dennis	DFO, Science	A	A
Schweigert	Jake	DFO, Science	A	A
Trudel	Marc	DFO, Science	A	X
Detering	Jackie	DFO, Science	A	X
Spence	Brenda	DFO, Science	A	X
External Participants				
Chalmers	Dennis	BC Ministry of Fisheries	A	A
Lenic	John	SIAB/CPSA	A	X
Yakimishyn	Jennifer	Parks Canada	A	A
Hill	Kevin	NOAA, sardine assessment	W	W
Hurtado-Ferro	Felipe	U of Wa	W	W
Thorson	James		W	W

A=attended

W=participation by Webinar/teleconference

X=did not attend

APPENDIX C: TERMS OF REFERENCE

Stock Assessment and Harvest Scenarios for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for the 2013 and 2014 Seasons

Regional Peer Review Meeting – Pacific Region

January 29-30, 2013

Nanaimo, British Columbia

Chairperson: Sean MacConnachie

Context

Pacific sardine (*Sardinops sagax*) from the Northeast Pacific (California Current) population has a distribution that can range between Baja California to southeast Alaska. In winter and spring months, most of the sardine population resides in waters off the California coast. Prior to and during summer months, large aggregations of sardine migrate from key spawning habitat to more northern waters, but migratory patterns can be affected by population size and oceanographic conditions. Typically, most sardines that migrate into B.C. waters are the larger and older component of the population.

Fisheries & Oceans Canada has been applying a Fishery Management Framework using a harvest control rule that sets the maximum annual total allowable catch (TAC) of sardine in B.C. waters based on annually updated biomass estimates of age 1 and older (1+) fish in the population, an estimated average seasonal migration rate of sardine into Canadian waters, and a regional harvest rate. Since 2002, average migration rate estimates applied to this harvest control rule have ranged from 10-27% in conjunction with a harvest rate of 15%, (Schweigert and McFarlane 2001, Schweigert et al. 2010, DFO 2012).

Since 1997, an index of the biomass of the migratory component of the sardine population present in B.C. waters has been determined from an annual summer surface trawl survey off the west coast of Vancouver Island (WCVI, Schweigert and McFarlane 2001). The index is based on average sardine trawl densities observed for the region, measured in t/km^3 . In addition to survey observations, sardine fishery catch locations have been considered to represent potential sardine habitat in unsurveyed areas. Biomass estimates for unsurveyed areas have been calculated by extrapolating annual trawl survey densities to spatial estimates of current and recent purse seine fishing grounds (Flostrand et al. 2011, DFO, 2012).

In anticipation of reductions in assessment funding, and to allow exploration of other important science questions related to sardine ecology, both DFO and the sardine fishing industry are interested in exploring alternative approaches to the provision of harvest advice that do not rely on a trawl survey. In addition, the fishing industry has expressed interest in having stability in the TAC. Moving towards multi-year science advice is consistent with Fisheries Modernization and is one of the key objectives of Fisheries Management. To address these multiple interests, both the provision of harvest advice and alternative approaches for the provision of harvest advice will be explored in this peer review process.

Objectives

The objectives of this peer review process are to:

1. Evaluate approaches for characterizing the migratory component of Pacific sardine biomass in B.C. waters (annually) that are not reliant on annual surveys.
2. Evaluate potential harvest rates respective of sardine population biomass estimates appropriate for fishing in B.C. waters
3. Consider the inclusion of a population biomass threshold parameter into a harvest control rule applicable to setting TACs in B.C. waters
4. Provide estimates of the 2012 mid-summer B.C. Pacific sardine seasonal biomass and migration rate
5. Identify any specific concerns, uncertainties or information gaps that should be considered when setting the TAC for the 2013 fishing season and from preliminary evaluation of competing harvest control rules.

Working Paper to be reviewed:

Flostrand, L., Schweigert, J., Bolt, J. and MacFarlane, S. Stock Assessment and Harvest Scenarios for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for the 2013 and 2014 Seasons (title subject to change). CSAP Working Paper 2012/P10

Expected Publications

- CSAS Science Advisory Report (1)
- CSAS Proceedings
- CSAS Research Document (1)

Participation

- DFO Science Branch
- DFO Fisheries Management Branch
- BC Ministry of Fisheries
- Commercial and recreational fishing interests
- First Nations organizations
- Non-government organizations

References Cited

- DFO 2012. Pacific sardine 2011 seasonal biomass and migration in British Columbia and harvest advice for 2012. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/026.
- Flostrand, L., Schweigert, J., Detering, J., Boldt, J. and MacConnachie, S. 2011. Evaluation of Pacific sardine (*Sardinops sagax*) stock assessment and harvest guidelines in British Columbia. DFO. Can. Sci. Advis. Sec. Res. Doc. 2011/096.
- Schweigert, J.F. and McFarlane, G.A. 2001. Stock assessment and recommended harvest for Pacific sardine in 2002. DFO. Can. Sci. Advis. Sec. Res. Doc. 2001/126: 13p.
- Schweigert, J., McFarlane, G. and Hodes, V. 2010. Pacific sardine (*Sardinops sagax*) biomass and migration rates in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/088. iii + 14 p.

APPENDIX D: WRITTEN REVIEWS

Review 1: James T. Thorson, Northwest Fisheries Science Center, NMFS

Major points:

1. Given low sample sizes and high interannual variation in availability (caused by fluctuations in the timing of the Pacific sardine migration in Canadian waters), it is quite reasonable to expect that updating estimates of migration rate every year (e.g., Scenario 1) will result in high interannual variance for harvest advice. If industry and management seek to minimize this variance, the alternative harvest control rules (Scenarios 2 and 3) seem appropriate and defensible. Additionally, a harvest control rule with a 150,000t cutoff (Scenario 3) should help to minimize risk of overfishing given a fixed harvest rate. Finally, it is widely acknowledged that a fixed total allowable catch (Scenario 4) is very sensitive to overfishing given changes in abundance. Therefore, the authors' proposal for switching to the Scenario 3 harvest control rule seems scientifically justifiable.
2. Alternatively, there is likely some improvement that could be made to decrease sampling variance for the current annual estimates of migration rates, and hence decrease interannual variance in harvest advice from Scenario 1. The authors' discuss the current migration rate estimate, which uses a 3-year moving average of migration rates derived from trawl survey off of Vancouver Island. This three-year moving average is a simple example of a model-based estimate, i.e. a way of applying an explicit or implicit population model to smooth variability in annual migration-rate estimates. Possible improvements in this model-based estimate include:
 - a) Relating previous, age-specific survey data to age-structured abundance estimates derived from Stock Synthesis to estimate an age-based migration rate. This could then be used to predict migration rates in a given year, based on SS estimates of age structure, and survey data could be used to update this estimate. This would essentially result in a mixed-effects estimator for annual migration rates, which would combine an expected value based on age-structure with results from the Vancouver Island survey. This type of age-structured migration model would therefore use auxiliary information (age-structured abundance estimates) to potentially improve the precision of survey estimates of migration rate.
 - b) Relating previous survey data to environmental covariates, e.g., ocean temperature. This appears justified based on the authors' observation that availability fluctuates due to the timing of Sardine migration, which in turn is affected by ocean temperature. Hence, incorporating environmental covariates could also potentially improve the precision of migration rate estimates.
 - c) These and other improvements in the model-based estimator for migration rates could be listed as a topic for future research, but are not necessary prior to changing the harvest control rule as discussed in this draft paper.
 - d) I also note (regarding TOR objective 2) that the proposed harvest rate of 3-5% in Scenarios 2-3 is based upon the average migration rate for all previous years. In addition, this estimate of average migration rate could potentially be improved by improvements in the model-based migration rate estimator, as explained above.
3. The authors' have suggested that using a harvest control rule that does not require annual migration rate estimates would allow the existing trawl survey to be conducted less frequently (perhaps every 2nd or 3rd year). However, high interannual variability in availability suggests that there is a large proportion of total sampling variance at the year-

level. This suggests that any decrease in total sample size would be more statistically efficient if it decreases the samples per year, rather than the number of years.

- a) Any attempt to optimize statistical efficiency for a fixed cost of sampling will therefore require information about the proportion of sampling variance at the haul- and year-level, as explained above. It will also depend upon the sampling cost-function, i.e., fixed costs (how expensive is it to prepare a boat and crew for sampling), vs. marginal costs (how expensive is each tow after having prepared the boat and crew). Finally, it will depend upon the purpose of the sampling, i.e., some measure of statistical risk or loss, which will depend upon the type of model-based smoothing that is used. These issues are not addressed in the attached manuscript, so I recommend that future research explicitly consider these issues before any change is made in the historical sampling protocol.
4. Pacific sardine is a highly dynamic population, and exhibits rapid changes in migration rate and abundance. The current harvest control rule (Scenario 1) uses Stock Synthesis abundance estimates from one year previous to management. This one-year lag between assessment estimates and management advice could result in important management delays in response to changing abundance. Management advice could perhaps be improved by coordinating more closely with the U.S. stock assessment team. In particular, the Stock Synthesis assessment could be projected forward one year, given catch targets and assumed natural mortality, and this one-year projection of abundance could be used within the Canadian harvest control rule. This could potentially decrease the difference between the nominal harvest target and the realized proportion of abundance that is harvested in any given year.
5. Finally, the authors' present both Stock Synthesis estimates of abundance at age, as well as the U.S. survey indices that are incorporated into Stock Synthesis. It is my impression that the U.S. Stock Synthesis assessment is designed to smooth out sampling variance for this stock, and therefore the presentation of Stock Synthesis estimates is recommended over the U.S. survey indices.

Review 2. Dennis Rutherford, DFO Assessment Biologist

Thank you for the opportunity to review CSAS Working Paper 2012/P10 titled Review of the harvest control rule and harvest advice for Pacific sardine (*Sardinops sagax*) in British Columbia waters for 2013 and 2014.

I would first like to commend the authors for the effort and time they have obviously put in to preparing and writing this document. I would also like to preface my review by stating that I am not familiar with and do not have experience in the assessment or management of straddling stocks so hopefully not all my comments are off base. My review primarily focuses on methods and the Harvest Control Rules, I then provide review/commentary on the sections of this document as they relate to delivery of science advice.

Although most of the paper was fairly well written I did have significant problems with the methods section. Methods do not provide sufficient information to determine if age and length composition of sardine in Canadian waters has been estimated correctly. Page 5 states 75-200 fish per tow were measured and then pooled by year to estimate age and length. If this is in fact what was done then the estimated length and age compositions presented are wrong. Sample size needs to be weighted by catch. A hypothetical example of this would be if only two tows made and one tow caught 1t and all age 1 and the second tow caught 9t and all age 3 if one simply pools an equal sample size from each of the two tows the estimate would be 50% age 1 and 50% age 3 when in fact the actual composition of the 10t population is 10% age 1 and 90% age 3.

The format of the methods section did not convey the basic methodological steps which I teased out to be: a) selection and description of 4 HCR's b) retrospective analysis to determine past catch and exploitation rates (note- not a true retrospective since the current view of past sardine population sizes were used, not what was available at the time c) evaluation of the performance of the 4 HCR options as they relate to catch and exploitation rates. If others encountered the same difficulty as me then I would suggest this section be revised.

The lack of equations made it difficult for a reader not familiar with sardine assessment to understand what was being done. The term modeled is referred to in all 4 scenarios but some of these scenarios did not have equations for the model, this was particularly troubling for understanding the first scenario/model. If text is going to be used to document a model then I suggest a format that is in perhaps bullet or step form as opposed to having model methodology buried in a lengthy left justified paragraph. My difficulty in understanding the methods was also compounded by the use of the word "scenario", it did not become evident until after several readings of the section that the word scenario was being used to refer to HCR "options" as well as output from the options, these are two different entities and the distinction needs to be made/included in the methods section. I still do not think I am clear on the distinction between scenario, simulation and model, all words used in the document.

Four HCR options are presented in the paper the 1) status quo a fixed HR applied to the DFO estimated migration rate into Canadian waters, 2) a fixed HR applied to the US estimated (through SS model) total biomass, 3) a fixed HR applied to the US estimated biomass in excess of 150,000 t and 4) a fixed TAC . How these 4 options were selected needs further explanation. In my opinion these HCR have some serious flaws.

- None of the 4 rules are compliant with the DFO Precautionary Approach (PA) policy. Any newly proposed HCR needs to incorporate at least some elements of the PA to show forward moving direction on compliance to the policy. The description of the HCR used in "scenario" 3 tries to imply that it incorporates the ramping down of fishing effort as the population decreases (an element of the PA). The paper goes on to try and make the case that it is a "convex" HCR as described by Zhang et al. 2013. This is certainly not the case, the "convex" HCR is based on F curves (F_{limit} and F_{target}), not a result of decreasing stock size interacting with a Limit Reference Point (LRP) as described on page 2. LRP's are an essential component of the PA and the only HCR proposed that has this element is the 3rd one. The paper discusses PA but makes no attempt to relate the HCR to the PA. If the HCR are thought to conform, or partially conform, to PA then the paper needs to be revised to include figures illustrating each of the HCR in the DFO PA three zone framework to allow for proper review..
- The rationale for the current "status quo" HCR eludes me. The basis or core of the DFO assessment for sardines seems to be based on the US estimate of stock size so why would the US 150,000 "cut off" be dismissed and not incorporated? This needs to be explained in the paper.

One obvious option for a HCR that does not seem to be considered is to fully embrace all aspects of the US SS assessment and assume all of the 13% assumed to be outside US waters is in Canada and then simply apply a HR to the Canadian component. I suggest this HCR option also be included and evaluated.

In the Conclusion and Advice section there is a recommendation to discontinue the status quo HCR because it results in variable exploitation rates; however, there is no supporting analysis to show that a variable ER is detrimental to the stock. I was confused at the way the "harvest Advice for the 2013-14 seasons" was presented. The harvest advice seemed to be an output of the HCR. This is conceptually wrong. The advice should be stock status based, the HCR then

dictates the harvest level, reading the output of a HCR is a management function not Science advice.

This paper seemed largely to be an industry and management exercise, none of the options considered are evaluated or grounded to science based levels for stock sustainability which is normally expected in a CSAS stock assessment document. All the evaluation appears to be grounded to management and fisher objectives only, no biological or conservation objectives seem to be considered or evaluated. Hence there should be no science advice coming out of this document. In this paper science has done the arithmetic to tabulate past catches and ER under various HCR's but the lack of evaluating against any biological or conservation objectives is a serious omission.

The paper states on Page 15 that management strategy evaluation (MSE) may be an approach that could inform and improve science advice regarding potential commercial harvest. From reviewing this paper MSE seems a long way off. Measurable conservation objectives are an essential component for MSE and there is no indication in this paper that they are developed or under development for the Canadian component.

Minor Comments

Paper mentions that a ramp down in HR as stock approached LRP is often referred to as a "hockey stick" HCR. I have never run across hockey stick used for HCR only for the shape of the Beverton Holt stock recruitment curve.

Appendices F, G, and H add nothing to the paper except colour.

Title of paper does not convey the main component of the paper which is an evaluation of HCR's designed to meet industry and management objectives.

I did not understand the argument on page 3 of the need to discontinue annual surveys (for estimating migration rates) due to anticipated reductions in funding, then throughout the paper it is stated that annual surveys will continue so one can "answer other important science questions". Not sure where the cost saving are and also no detail on what the "other important science questions" are.

There did not seem to be good linkage between Terms of Reference and Working Paper.

Again, thank you for the opportunity to review and I hope that at least some of my review comments are valuable.